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GRAIN DRYING AT A COUNTRY ELEVATOR [1]

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MOISTURE CONTENT OF GRAIN

The market value and storage qualities of grain depend to a large extent upon its moisture content. When in sound, marketable condition wheat, oats, barley, and rye produced in the spring-wheat areas have a moisture content varying from 11 to 14.5 per cent, and flax from 8 to 10 per cent. The Federal grain standards specify maximum moisture contents for grade No. 1 as follows: Spring and durum wheat 14 per cent, all other wheat 13.5 per cent; oats, 14 per cent; rye, 13 per cent; barley grown east of the Rockies, 14.5 per cent, and barley grown west of the Rockies, 13.5 per cent. Cereal grain containing more than the maximum moisture content specified for grade No. 1 is assigned to a lower grade. Grain containing moisture much in excess of that specified for grade No. 1 may be seriously damaged in storage or in transportation to market.

Weather conditions, storage facilities, and prevalence of broken kernels in the grain each influence to some extent the maximum moisture content that grain contains to be safe for storage, but under average conditions grain containing not over the maximum moisture content specified for grade No. 1 is considered sufficiently dry for safe storage.

Table 1 shows the percentage of Government-supervised receipts that fall in numerical grades below No. 1, either directly or indirectly because of moisture, for hard red spring and durum wheat at Duluth and Minneapolis, Minn., for 1924 to 1928, inclusive. This table is not entirely representative of all wheat received at these terminals, because the inspection of only a part of the grain is subjected to Federal supervision. However, it shows that a large percentage of wheat falls within the lower grades because of high moisture content.

[1] Acknowledgment is made to E. E. Robideaux of the Robideaux Grain Co., Parshall, N. Dak., who made available the facilities for conducting these tests, and to the Otter Tail Power Co., Fergus Falls, Minn., for the loan of electrical equipment.

TABLE 1.—*Percentage of cars of hard red spring and durum wheat received, 1924–1928, at Duluth and Minneapolis, Minn., graded by Federal inspectors, and placed in grades below No. 1 due directly or indirectly to moisture content alone or to moisture content combined with one or more other grading factors*

DULUTH

Grading factor	1924		1925		1926		1927		1928	
	Hard red spring	Durum	Hard red spring	Durum	Hard red spring	Durum	Hard red spring	Durum	Hard red spring	Durum
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Moisture	19.5	38.8	6.2	18.1	25.3	56.8	16.7	16.5	6.9	11.1
Musty	.2	.2	.2	.5	.6	1.0	.8	.7	.5	.4
Sour	0	0	0	.1	0	.2	.1	.3	0	.1
Heat damaged	1.2	.7	.6	2.3	1.3	3.0	1.1	1.3	1.4	1.0
Hot or heating	0	0	.1	.1	.1	.1	.2	.1	.2	.2
Total	20.9	39.7	7.1	21.1	27.3	61.1	18.9	18.9	9.0	12.8
MINNEAPOLIS										
Moisture	11.0	10.1	5.9	5.5	25.9	33.0	18.1	10.3	7.6	13.9
Musty	.2	.2	.4	.3	.7	1.1	.4	.3	.2	.4
Sour	0	0	0	0	0	.2	0	.3	0	.3
Heat damaged	1.4	1.7	.8	.5	1.7	3.1	.9	2.4	1.2	.9
Hot or heating	0	0	.1	0	0	.2	.1	0	0	0
Total	12.6	12.0	7.2	6.3	28.3	37.6	19.5	13.3	9.0	15.5

Threshing of grain before it is thoroughly dry, uneven ripening of the grain, presence of green weed seeds in the threshed grain, unfavorable weather condition during the threshing season, starting the combine before the grain is dead ripe or too soon after dews or rains, or a combination of these factors, is largely responsible for a moisture content in the grain that is frequently too high for safe storage and transportation, or to enable the grain to meet the moisture content requirements for the higher grades. Such grain must be dried in some manner before it can be safely stored or shipped.

Small quantities of threshed grain that contain only a slight excess of moisture may be dried slowly in properly ventilated farm bins or by repeated aeration, but such methods are not applicable to large quantities of grain nor to grain that must be made fit for commercial use without undue delay.

The introduction of the combined harvester-thresher into new areas has emphasized the need for practical methods for drying grain at country points. The combine, under favorable weather and crop conditions, usually saves time, labor, and expense. However, rain during the harvest season may delay the cutting and reduce the market value of the grain; weeds may hinder combining; the green weed seeds and dockage may add to the moisture content of the threshed grain; and in some localities uneven ripening and other causes of high moisture content may offset the advantages of the use of the combines unless some convenient, efficient, and inexpensive method of drying is available.

NEED OF GRAIN DRIERS

During recent years considerable interest has developed in the artificial drying of grain at country elevators. Commercial grain driers are commonly used for drying grain at terminal markets. Such driers designed for use at country elevators are now on the market. A comparatively new method of harvesting grain includes the use of the windrower by which the grain is first cut and placed in windrows to dry, and later picked up and threshed with the combine. The windrower and pick-up are used principally where the grain fields are weedy, or in fields that do not ripen evenly. A satisfactory grain drier available within hauling distance would eliminate the extra work and expense of windrowing, except possibly in fields that are too weedy to permit of efficient direct combining and for some crops that do not mature uniformly. A satisfactory method of drying grain artificially would also permit combining earlier in the season, and sooner after rains and dews. Thus it would reduce the number of days required for harvesting, the advantages of which lie not only in time saved for other work but also in the harvesting of the crop before deterioration from wet weather with its consequent lowering of test weight and quality. Moreover, some of the hazards to standing grain, such as hail, high winds, and heavy rains, would be avoided.

One of the problems in the past has been to secure a drier of sufficient capacity that could be purchased and operated at a cost low enough for use at country points which are located near the fields from which the grain is cut. Two general types of commercial grain driers are now manufactured in a size suitable for use at country elevators. One type, generally known as the steam-heated drier, uses air heated by steam, the other type, usually referred to as the direct-heat drier, utilizes for drying the combustion gases direct from a furnace, mixed with outside air. Both types employ fans to force the heated air through the grain.

During the 1929 harvest season investigations were conducted by the Department of Agriculture to determine some of the mechanical and economic factors involved in the artificial drying of grain with a small-sized commercial drier located at a country elevator. This work was done at Parshall, N. Dak., and data were secured regarding the power, labor, and fuel requirements, and the market values of the grain before and after drying. During the time that observations were made 6,727 bushels (gross) of wheat and 4,174 bushels of rye were dried.

During the season a total of about 20,000 bushels of grain was passed through the drier. The 1929 harvest season was unusually dry and very little rain fell during the entire harvest. Relative humidity and precipitation were both below the average. These factors undoubtedly reduced the quantity of grain that needed drying at that station.

DESCRIPTION OF A COMMERCIAL DRIER

Grain driers of various makes, types, and sizes are on the market at present but practically all of them are similar in that the drying air is forced through layers of grain usually from 4 to 6 inches thick. The commercial drier on which observations were made was of the type generally known as the direct-heat drier. In this type, hot

gases are drawn from a furnace, mixed with outside air in a mixing chamber to produce the desired temperature, and then forced through the grain by a fan. The temperature of the mixture of the furnace gases and air was controlled by a thermostat which, by means of air pressure actuated a series of dampers regulating the quantity of hot and cold air admitted.

The drier was made of sheet metal and had a cross section of approximately 5 by 8 feet and an over-all height of about 26 feet. The drier was divided horizontally into two bins containing intake and exhaust flues. Hot air from the furnace was supplied to the upper bin for drying, and atmospheric air was used in the lower bin for cooling the grain. The bins were separated by plate valves, and a separate fan was used for each bin. The rated capacity of the drier was 250 bushels of wheat per hour and it could be used for either batch or continuous operation. A diagrammatic section of the drier is shown in Figure 1 and a photograph of the elevator and drier building in Figure 2.

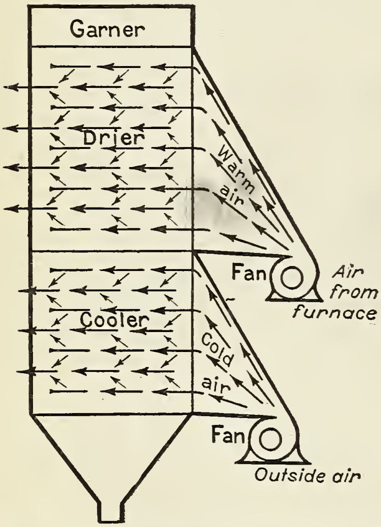

FIGURE 1.—A diagrammatic section of a grain drier

Air from the fans entered the grain through a series of intake flues, was forced through the grain, and allowed to escape through exhaust flues to the atmosphere. The ends of the intake flues were open on the side of the drier next to the fans but were closed at the opposite side. The exhaust flues were closed on the side next to the fans but were open to the atmosphere at the other side of the drier. The arrangement of the flues is shown in Figure 3.

Grain to be dried was fed by gravity into the garner at the top of the drier from a storage bin in the elevator building. The grain passed down through the drier and cooler bins by gravity and was then conveyed to a pit in the elevator building by means of a screw conveyor. The discharge rate, measured by the length of time the grain remained in the drier when operated as a continuous unit, was regulated by valves at the bottom of the hopper under the cooler bin.

Four electric motors were employed to operate the drier and auxiliary equipment. A ½-horsepower motor was used on a scalper or cleaner mounted on top of the drier bin. The drier and cooler fans were each driven by a 5-horsepower motor and the discharge auger was driven by a 2-horsepower motor. Grain from the drier was conveyed by the discharge auger to a pit in the elevator building. The bucket elevator used for elevating this grain was operated by a 7½-horsepower motor. This motor and the bucket elevator were not a part of the drier equipment, but the power consumed in elevating the artificially dried grain was determined.

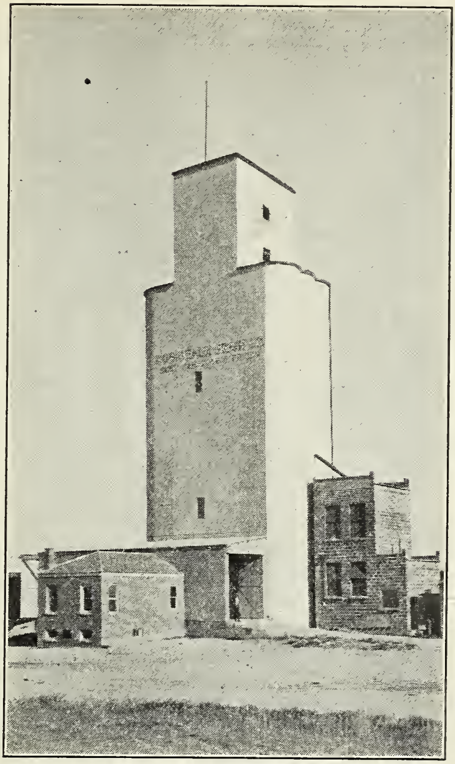

FIGURE 2.—Elevator and grain-drier building

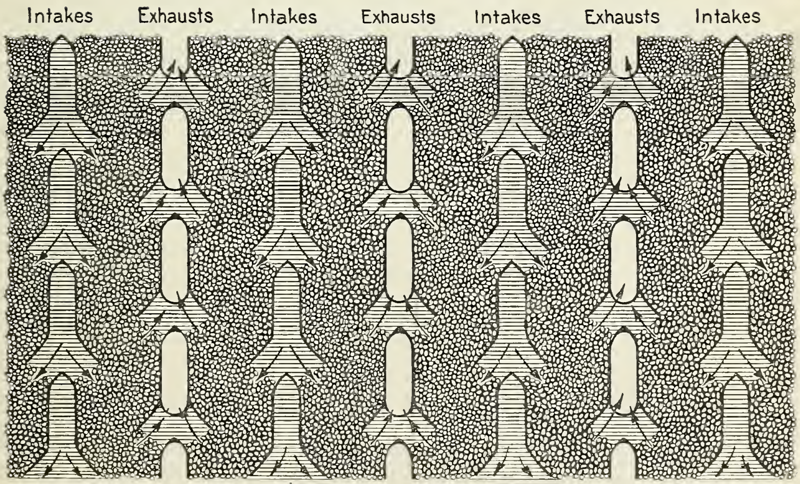

FIGURE 3.—Section of a grain-drier bin

OPERATION OF DRIER

Frequently grain that contains a large percentage of dockage is brought to a drier. Damp or wet grain containing dockage has a tendency to clog in grain pipes and in hopper bottom bins. The common rules applied in determining the proper slope for hopper bottom bins and the size and slope of grain pipes are not applicable if damp or wet grain is to be handled. When grain is to be fed into the drier by gravity from a storage bin, provision should be made for filling the drier quickly. If this is not done as much time may be spent in filling the drier bin as in drying a small lot of grain.

When operating with the grain in continuous flow through the machine, the rate at which grain is fed into the drier should be controlled automatically by the discharge rate. If this is not done it will be necessary for the operator to make frequent trips to the top of the drier to regulate the flow of grain. This is especially true if a cleaner or scalper is installed on top of the drier with no provision for automatic control. Drying operations will be simplified if grain containing a large percentage of coarse dockage is at least partly cleaned, before it is placed in the bin from which it is fed into the drier.

Air is relatively a poor conductor of heat. For this reason it is necessary that the flue gases and air be thoroughly mixed if a uniform temperature is to be obtained. It is essential that the thermometer used to indicate the temperature of the drying air be placed in a position where it is not influenced by outside temperatures, by radiation, or by eddy currents in the air duct. Two thermometers which, if held in the same relative position in an air duct, would indicate practically the same temperature, have been known to show a considerable variation when held in different positions in the duct, owing to one or more of the above causes.

Tests made with an experimental drier in 1928 [2] showed that about one hour was required to reduce the moisture of wheat, barley, rye, and buckwheat from approximately 20 per cent to 14 per cent with the drying air at 160° F. Considerably less time was required for drying such grain containing less than 20 per cent moisture, and for drying oats. Oats, at a given moisture content, contain a smaller quantity of water per bushel than do the other grains, because fewer pounds constitute a bushel.

An air temperature of 180° F.[3] is considered as the maximum allowable temperature for drying wheat without injury to the milling and baking qualities, and unless the temperature of the drying air can be accurately controlled it is advisable to operate at a slightly lower temperature. This is especially true if the grain is high in moisture content. Tests [4] have shown that the germination of wheat, rye, oats, and buckwheat apparently was not impaired by artificial drying with heated air at 120°, 140°, or 160°.

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[2] BENTON, A. H., BLACK, R. H., HUMPHRIES, W. R., HURST, W. M., MANGELS, C. E., MILLER, R. C., and others. THE COMBINED HARVESTER-THRESHER IN NORTH DAKOTA, N. Dak. Agr. Expt. Sta. Bul. 225. 49 p., illus. 1929.

[3] SHERWOOD, R. C. EFFECTS OF WHEAT DRYING UPON MILLING AND BAKING PROPERTIES. Minn. State Dept. Agr. Dairy and Food Bul. 66, 36 p., illus. 1929. CANADA NATIONAL RESEARCH COUNCIL. THE DRYING OF WHEAT. Canada Council Sci. and Indus. Research Rpt. 24, 122 p., illus. 1929.

[4] BENTON, A. H., BLACK, R. H., HUMPHRIES, W. R., HURST, W. M., MANGELS, C. E., MILLER, R. C, and others. Op. cit.

POWER CONSUMPTION

The amounts of power consumed in cleaning the grain with the scalper, in drying and cooling, in conveying the artificially dried grain to a pit in the elevator building, and in elevating it into a storage bin, are shown in Table 2 for the various lots of grain dried. Slightly more power was used in cooling the grain than in drying it, probably because more air was moved by the cooler fan than by the drier fan. There were no obstructions on the intake side of the cooler fan while both the mixing chamber and furnace were on the intake side of the drier fan. These units offered some resistance to the flow of air.

TABLE 2.—*Power and fuel consumed, and approximate operating costs of the drier at Parshall, N. Dak., 1929*

WHEAT

Lot No.	Grain: Quantity dried [1]	Grain: Reduction in moisture	Air: Atmosphere	Air: Relative humidity	Air: Entering grain [2]	Power consumed by—: Scalper motor	Power consumed by—: Drier motor	Power consumed by—: Cooler motor	Power consumed by—: Discharge motor	Power consumed by—: Elevator motor	Power consumed by—: Total power	Power consumed by—: Cost [3]	Labor cost [4]	Fuel: Coal	Fuel: Cost [5]	Operating cost: Total	Operating cost: Per bushel [1]
	Bushels	*Per cent*	°*F.*	*Per cent*	°*F.*	*Kilowatt-hours*	*Kilowatt-hours*	*Kilowatt-hours*	*Kilowatt-hours*	*Kilowatt-hours*	*Kilowatt-hours*	*Dollars*	*Dollars*	*Pounds*	*Dollars*	*Dollars*	*Dollar*
1	1,100	2.7	73.4	49.7	197.4	0.8	10.4	12.1	1.5	6.6	31.4	2.20	2.20	343	2.14	6.54	0.0059
2	800	3.3	72.6	58.5	202.1	.8	8.8	13.9	1.3	5.4	30.2	2.11	1.60	323	2.02	5.73	.0072
3	1,066	3.8	79.7	21.7	197.0	.6	13.1	12.7	1.4	7.2	35.0	2.45	2.13	499	3.12	7.70	.0072
4	523	5.8	70.9	32.0	191.4	.5	7.8	10.2	.2	2.9	21.6	1.51	1.05	243	1.52	4.08	.0078
5	800	3.4	87.0	22.4	195.0	.4	10.6	11.7	1.1	6.0	29.8	2.09	1.60	357	2.23	5.92	.0074
6	300	3.8	80.3	33.1	191.9	.1	2.9	3.3	.3	1.5	8.1	.57	.60	134	.84	2.01	.0067
7	1,471	3.2	75.9	26.7	166.8	.4	12.3	14.3	1.5	8.1	36.6	2.56	2.94	371	2.32	7.82	.0053
8	400	3.5	85.1	43.9	194.7	.1	5.6	5.7	.3	2.4	14.1	.99	.80	237	1.48	3.27	.0082
Total	6,460					3.7	71.5	83.9	7.6	40.1	206.8	14.48	12.92	2,507	15.67	43.07	
Average		3.5	78.1	36.0	192.0												.0067

RYE

Lot No.	Grain: Quantity dried [1]	Grain: Reduction in moisture	Air: Atmosphere	Air: Relative humidity	Air: Entering grain [2]	Power consumed by—: Scalper motor	Power consumed by—: Drier motor	Power consumed by—: Cooler motor	Power consumed by—: Discharge motor	Power consumed by—: Elevator motor	Power consumed by—: Total power	Power consumed by—: Cost [3]	Labor cost [4]	Fuel: Coal	Fuel: Cost [5]	Operating cost: Total	Operating cost: Per bushel [1]
9	1,200	4.6	76.4	32.3		(6)	14.2	17.1	1.5	3.6	36.4	2.55	2.40	310	1.94	6.89	0.0057
10	500	3.5	84.6	22.7		(6)	7.2	6.9	.3	2.9	17.3	1.21	1.00	213	1.33	3.54	.0071
11	750	4.9	81.7	33.2		1.5	13.3	17.9	1.8	9.3	43.8	3.07	1.50	698	4.36	8.93	.0119
12	1,200	4.3	65.1	39.7	182.4	1.4	19.6	21.1	1.6	15.8	59.5	4.16	2.40	702	4.39	10.95	.0091
13	243	5.6	81.9	31.6	177.6	.3	6.1	4.3	.3	1.3	12.3	.86	.49	192	1.20	2.55	.0105
Total	3,893					3.2	60.4	67.3	5.5	32.9	169.3	11.85	7.79	2,115	13.22	32.86	
Average		4,5	77.9	31.9	180.0												.0084

[1] Net bushels as received at elevator, dockage not included. For gross amount including dockage. and percentage of dockage in each lot, see Table 3.
[2] Approximate.
[3] Power at 7 cents per kilowatt-hour
[4] Labor at $5 per day.
[5] Coal at $12.50 per ton.
[6] Before scalper was installed.

The 7½-horsepower motor used for elevating the artificially dried grain operated under only a fractional part of its rated load while the drier was in operation. For this reason the power consumed in elevating the grain was much more than would have been required with a motor and elevator of suitable size for elevating 250 bushels of grain per hour.

FUEL

Briquets of semibituminous coal were used as fuel. Analyses of samples of this fuel made by the Bureau of Mines show an average heating value of approximately 12,500 British thermal units per pound as fired at Parshall, N. Dak. Hard coal or coke is recommended for use with the direct-heat type of drier as these fuels give off less smoke and fewer sparks than does soft coal. Sparks from unsuitable fuels have been known to cause considerable trouble with grain containing a high percentage of chaff and straw. The actual danger from fire in this connection does not seem serious if proper precautions are taken. When a spark from the furnace ignites chaff or straw in the drier a mass of smoldering grain is soon formed, and smoke can be seen emerging from that section of the drier. Considerable time is often lost, and difficulties are experienced in locating, removing, or breaking up the smoldering mass.

The quantity of fuel required for drying grain under any given set of conditions depends in part upon the quantity of water to be evaporated from a unit quantity of grain, the heating value and physical properties of the fuel, the efficiency of the furnace and drier, weather conditions, and the quantity of grain to be dried under continuous operation. Under the test conditions the grain was dried in small quantities, as shown in Table 2, necessitating some waste of fuel. On the other hand, weather conditions were ideal for drying.

LABOR

It is advisable to have the drier under the supervision of one person who has no other duties to interfere during the operation. Driers are designed to operate with little attention, but better results will be obtained if the drier is under constant observation. The temperature of the drying air should be watched closely, and fuel may be utilized effectively by timely firing. With the direct-heat type of drier the temperature of the drying air is controlled automatically, but a leak in the air line from the air compressor or a failure of the thermostat to function properly may cause trouble if not given prompt attention.

ELEMENTS OF COST

Power, fuel, labor, interest on investment, and depreciation of equipment are considered in this report in connection with the cost of drying. Electric energy was supplied at 7 cents per kilowatt-hour. The coal used cost about $12.50 per ton delivered. During the 1929 season no extra help was employed for operating the drier on which observations were made. Under ordinary conditions, however, one man would be needed during the busy season if the best results are to be obtained. A labor charge of $5 per day is included in the cost figures. For continuous operation of the drier during the day the cost of labor on this basis would approximate 0.2 cent per bushel of grain dried. As this employee's time would be utilized in

other work about the elevator when the drier was not in operation, the labor cost is considered as 0.2 cent per bushel of grain dried.

Approximately $7,000 was invested in grain-drying equipment at Parshall. Of this amount about $4,000 represents the cost of machinery and equipment, installed, and $3,000 the cost of the building in which the drier was housed. In computing the fixed charges a rate of 6 per cent was used as interest on investment, 8 per cent as depreciation on machinery and equipment, and 3 per cent as depreciation on the building. On this basis depreciation and interest on investment represent a fixed cost of $830 per year.

The cost of power, labor, and fuel are shown in Table 2 for individual lots of grain. The operating expenses of the drier per bushel of grain dried, varied from day to day, depending in part upon the quantity of water evaporated, quantity of grain dried in continuous operation, weather conditions, kind of grain dried, and skill of the

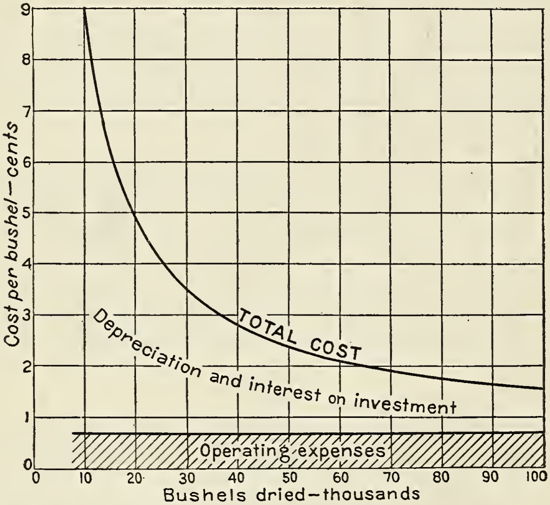

FIGURE 4.—Approximate relation between cost of drying wheat and number of bushels dried per season based on 1929 operating conditions for a drier with a rated capacity of 250 bushels per hour representing an investment of approximately $7,000

operator. Interest on investment and depreciation of equipment constitute a fixed annual cost, but when computed on a per-bushel basis these fixed charges decrease as the total volume of grain dried per season increases.

The relation between the total cost of drying wheat and the number of bushels dried per year, based on the 1929 observations, is shown in Figure 4. The operating expense (power, labor, and fuel) is the average as shown in Table 2 for wheat on a per-bushel basis. This expense would not be constant throughout the season but the value shown with current at 7 cents per kilowatt-hour, labor at $5 per day, and fuel at $12.50 per ton, probably is representative of a drier of the size and type used under the test condition. As shown in Figure 4 the item of depreciation and interest on investment makes up the largest part of the total cost of drying unless a considerable quantity of grain is dried per year.

MOISTURE, TEST WEIGHT, AND DOCKAGE DETERMINATIONS

Moisture, test weight, and dockage determinations were made at this plant during the drying of 6,460 bushels of wheat and 3,893 bushels of rye, a total of 10,353 bushels net or 10,901 bushels gross, including the dockage. Samples were taken at half-hour intervals of the grain entering the drier and of that discharging from the cooling section of the drier.

The average moisture, test weight, and dockage before and after drying were then determined from each lot of grain processed. Records were made on 8 lots of wheat including 1 lot of durum wheat, and on 5 lots of rye. The number of samples taken from each lot and the average of determinations made on the samples taken from each lot are shown in Table 3, together with the quantities represented in each lot.

TABLE 3.—*Test data and market value of wheat and of rye before and after drying*

WHEAT

Lot No.	Time of test (before or after drying)	Gross quantity	Samples taken	Moisture content (average)	Test weight (average)	Dockage (average)	Grade of grain	Net quantity	Price per bushel[1]	Total value	Increase in value
		Bushels	*Number*	*Per cent*	*Pounds*			*Bushels*	*Dollars*	*Dollars*	*Dollars*
1	Before	1, 136	8	17. 7	52. 9	3. 2	Sample.	1, 100	0. 80	880. 00	
	After	1, 100	7	15. 0	53. 3	2. 6	4	1, 072	. 93	996. 96	116. 96
2	Before	841	7	18. 9	53. 5	4. 8	Sample.	800	. 78	624. 00	
	After	808	6	15. 6	54. 3	4. 0	4	776	. 93	721. 68	97. 68
3	Before	1, 110	10	18. 1	54. 5	4. 0	Sample.	1, 066	. 80	852. 80	
	After	1, 061	9	14. 3	55. 5	3. 4	3	1, 025	. 99	1, 014. 75	161. 95
4[2]	Before	568	6	19. 8	55. 7	8. 0	Sample.	523	. 70	366. 10	
	After	530	6	14. 0	57. 5	5. 4	3	501	. 93	465. 93	99. 83
5	Before	818	8	16. 6	55. 3	2. 2	Sample.	800	. 82	656. 00	
	After	786	7	13. 2	55. 9	2. 7	3	765	. 99	757. 35	101. 35
6	Before	314	3	15. 8	57. 2	4. 4	4	300	. 93	279. 00	
	After	300	3	12. 0	[3] 56. 6	2. 6	3	292	. 99	289. 08	10. 08
7	Before	1, 504	8	15. 6	58. 2	2. 2	4	1, 471	. 93	1, 368. 03	
	After	1, 449	10	12. 4	59. 0	2. 2	1	1, 417	1. 08	1, 530. 36	162. 33
8	Before	436	4	16. 7	55. 7	8. 2	Sample.	400	. 82	328. 00	
	After	418	5	13. 2	57. 2	5. 7	2	394	1. 05	413. 70	85. 70
Total	Before	6, 727						6, 460		5, 353. 93	
	After	6, 452						6, 242		6, 189. 81	835. 88

RYE

Lot No.	Time of test (before or after drying)	Gross quantity	Samples taken	Moisture content (average)	Test weight (average)	Dockage (average)	Grade of grain	Net quantity	Price per bushel[1]	Total value	Increase in value
9	Before	1, 322	8	20. 8	49. 3	9. 2	Sample.	1, 200	0. 65	780. 00	
	After	1, 249	9	16. 2	50. 9	7. 5	do	1, 155	. 73	843 15	63. 15
10	Before	532	3	17. 1	51. 4	6. 0	do	500	. 72	360. 00	
	After	510	4	13. 6	52. 2	6. 7	3	476	. 76	361. 76	1. 76
11	Before	813	10	17. 5	51. 2	7. 7	Sample.	750	. 71	532. 50	
	After	767	4	12. 6	52. 5	4. 9	3	730	. 76	554. 80	22. 30
12	Before	1, 254	10	17. 4	52. 0	4. 3	Sample.	1, 200	. 71	852. 00	
	After	1, 192	13	13. 1	53. 2	4. 3	3	1, 141	. 76	867. 16	15. 16
13	Before	253	4	17. 4	50. 0	3. 8	Sample.	243	. 71	172. 53	
	After	237	3	11. 8	52. 3	3. 1	3	230	. 76	174. 80	2. 27
Total	Before	4, 174						3, 893		2, 697. 03	
	After	3, 955						3, 732		2, 801. 67	104. 64

[1] Prices based on Table 4.
[2] Durum wheat.
[3] The apparent lowering of test weight is unexplained.

LOSS IN WEIGHT DUE TO DRYING

Since dockage is included in the grain upon which moisture determinations are made, the shrinkage in weight must be calculated upon the gross weight, or gross bushels of grain as received at the

elevator. The following formula, used in determining the number of gross bushels after drying, was taken from information in another publication of this department.[5]

$$\frac{\text{Gross bushels before drying} \times (100 - \text{per cent moisture before drying})}{(100 - \text{per cent moisture after drying})} = \text{Gross bushels after drying.}$$

Example: (Lot 9) Given 1,322 gross bushels of wheat containing 20.8 per cent moisture before drying and 16.2 per cent moisture after drying.

$$\frac{1{,}322 \times (100 - 20.8)}{(100 - 16.2)} = \frac{1{,}322 \times 79.2}{83.8} = 1{,}249$$

There is always a larger percentage of decrease in gross bushels than the actual difference in percentage of moisture before and after drying, because of the larger percentage of dry matter in the samples of dried grain as samples of equal weight are used for each moisture determination. In the case of lot 9 there was a decrease of 4.6 per cent in moisture and of 5.5 per cent in total weight. The average decrease in moisture in all of the wheat dried, including the dockage, was 3.5 per cent and in the rye 4.5 per cent; the average decrease in weight of the gross wheat was 4.1 per cent and of the rye 5.2 per cent.

Most of the grain cut with combines in the spring-wheat area contains green-weed seeds. These seeds have a higher moisture content than does the grain itself, and in drying a larger percentage of moisture is expelled from the weed seeds than from the grain. There is also a slight reduction in dockage due to the chaff and other light foreign material which is blown out of both the heating and cooling sections of the drier.

Since a larger percentage of moisture was removed from the dockage than from either the wheat or the rye (except in lots 5 and 10) the remaining number of net bushels of grain after drying was greater than normally would be expected. The dockage in lots 5 and 10 consisted principally of wild oats which were drier than the grain; accordingly a smaller percentage of the moisture was removed from these than from the rye and wheat. Therefore, in lots 5 and 10 there was a greater loss of net bushels than would be anticipated.

DRYING INCREASES TEST WEIGHT

The drying of grain increases its test weight. The increase is often sufficient to give the grain a higher numerical grade. Four of the eight lots of wheat were each thus raised one grade when the test weight was considered as the only grading factor. An appreciable increase in test weight was found in all of the lots dried except lot 6. This apparent decreased test weight has not been explained, unless as a possible experimental error due to uneven mixture of several widely different test weights in the loads of the grain in this lot.

INCREASE IN MARKET VALUE

The purpose of artificial drying is to eliminate storage hazards and to increase the market value of the grain. The average grade and market value both before and after drying for each lot of grain tested

[5] DUVEL, J. W. T. MOISTURE CONTENT AND SHRINKAGE OF GRAIN. U. S. Dept. Agr., Bur. Plant Indus. Circ. 32, 13 p. 1909.

are shown in Table 3. The prices in Table 4 are the averages of prices quoted for Parshall, N. Dak., during the period August 8 to 20, 1929, when these drying experiments were conducted. The drying process resulted in an increased market value for all lots dried. A maximum increase of 23 cents per bushel was obtained in the case of the wheat in lot 8. The average gain in market value was much greater for the wheat than for the rye. The maximum increase for the rye was but 8 cents per bushel, which was less than the average increase for the wheat. The increase in market value was partly offset by the decrease in net bushels during the drying.

TABLE 4.—*Prices of wheat and rye at Parshall, N. Dak., during the period of the drying tests*

Kind of grain	Grade	Price per bushel [1]	Kind of grain	Grade	Price per bushel [1]
		Dollars			*Dollars*
Dark northern spring wheat	1	1.08	Do	3	.93
Do	2	1.05	Do	4	.87
Do	3	.99	Do	5	.78
Do	4	.73	Do	Sample.	(3)
Do	5	.84	Rye	2	.78
Do	Sample.	(2)	Do	3	.76
Durum wheat	1	.99	Do	4	.74
Do	2	.97	Do	Sample.	(4)

[1] These prices are averages of prices quoted at Parshall, N. Dak., Aug. 8 to 20, 1929.
[2] With grade No. 5 as base, 1 cent discount for each 0.5 per cent moisture over 16 per cent and 3 cents discount for each 1 pound test weight under 50 pounds.
[3] With grade No. 5 as base, 1 cent discount for each 0.5 per cent moisture over 16 per cent and 3 cents discount for each 1 pound test weight under 51 pounds.
[4] With grade No. 4 as base, 1 cent discount for each 0.5 per cent moisture over 16 per cent and 2 cents discount for each 1 pound test weight under 49 pounds.

NET GAIN IN MARKET VALUE

The net gain in market value of the various lots of grain dried was determined by subtracting the total value of each lot before drying from the total value after drying. In the case of wheat the average gain was 12.9 cents per bushel with a total gain in market value of $835.88 in drying 6,460 net bushels. The least gain obtained for wheat was shown in drying the 300 bushels in lot 6. The apparent error in test weight for this lot partly accounts for this small gain.

No value was assigned to the dockage in the grain when received at the elevator. Because of its excessive moisture content much of the dockage was of no value before drying. There were approximately 12,600 pounds of dockage after drying, which had a value of about $94.50. This would about pay the expense of cleaning the wheat under the conditions existing at this particular elevator.

The net gain in market value of the 3,893 bushels of rye was $104.64, or 2.7 cents per bushel. A maximum gain of 5.3 cents per bushel was obtained on lot 9 which contained 1,200 bushels. This lot was very wet before drying and should have been redried except for the fact that it was mixed with dry rye to meet the grade requirements.

Apparently less is to be gained by drying rye than wheat. On the other hand, a large percentage of rye, as received, contains a high moisture content and often must be dried to prevent damage in storage.

The increase in local market value of the wheat and rye resulting from drying does not necessarily reflect the total gain. When damp or wet grain is taken to an elevator it frequently has to be held in storage for several days. Grain is also usually en route in railroad cars for several days before it arrives at a terminal market. High moisture content not only causes the grain to be assigned to a grade lower but may cause the grain to go out of condition. When such grain is finally sold on the terminal market it takes a heavy discount, which could be avoided by drying the grain locally.

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August 22, 1930

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